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Art. IV.—*The San Remo Peninsula.*

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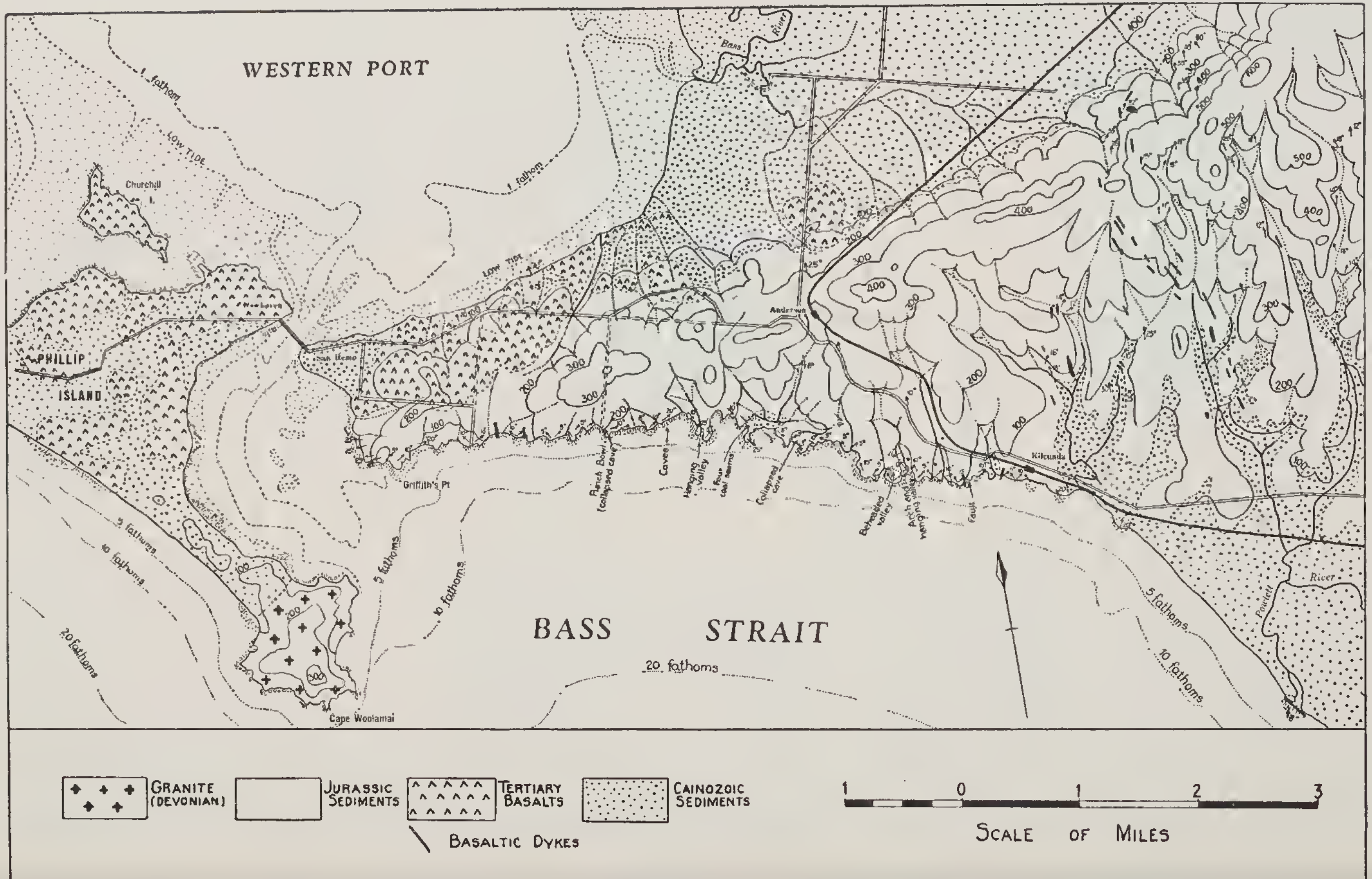
Contents.

Introduction.

The San Remo Peninsula is that arm of the land, about six miles long and from one to one and a half miles wide, that extends westwards from the south-eastern corner of Western Port Bay (Text Map). It is composed of Jurassic sediments, capped by Tertiary gravels and basalts (Stirling, 1893), and consists of a tilted horst, which is the westerly extension of the Bass Ranges, one of the major fault blocks of the South Gippsland Highlands. On the north side it is bounded by the Bass Fault, while on its southern side it was originally bounded by the Kongwak Fault (Hills, 1940, fig. 347). The throw of these faults died away towards the west. This is shown by the decreasing height of the Bass Range horst in this direction, from well over 1,000 feet above sea-level at Strezlecki to about 900 feet at Krowera, and Bass Hill, 600 feet at Steenholdt's Hill, 400 feet near Kilcunda, and to about 200 feet at San Remo.

The horst is tilted to the north at an angle of about 5° throughout the Peninsula. This is proved by the disposition of the Tertiary basalts, which occur only on the northern side of the Peninsula, sloping down from about 200 feet above sea-level on the hill tops to below sea-level on the northern coast, as a capping on the Jurassic sediments. At the eastern end of the Peninsula, near the Anderson Railway Station, cuttings along the Melbourne-Wonthaggi road where it climbs the Bass Scarp show that the basalt occurs only on the lower slopes of the Scarp, overlying a tilted Jurassic surface. This tilt must have caused the drainage to develop chiefly as north-flowing, back-slope streams, with much shorter streams flowing southwards over the steep southern scarp. The south-flowing streams, with their steeper gradients, have cut down rapidly into the Jurassic sediments exposed in the scarp, and by headward erosion have



Text Map: Geological Sketch Map of the San Remo Peninsula.

undermined and stripped off the basalt from the southern side of the block, where its former presence is revealed only by dykes As the scarp matured, the greater vigour of the south-flowing streams caused the divide to migrate northwards to its present position close to the northern margin of the horst. Ferguson (1909) notes that the tilt persists throughout the Bass Range (Quarter Sheet 67 N.E.), where many of the individual hills show a gentle dip slope to the north and a steep scarp to the south, and that it steepens towards the northern edge of the range, suggesting that in this region a monoclinal structure is associated with the Bass Fault. The author has noted almost vertical beds adjacent to the scarp near Nyora; and a comparable steepening of the northerly dip occurs along the northern coast of the Peninsula.

The surface of the granitic stock that forms the south-eastern end of Phillip Island also slopes to the north at an angle of 5° (Plate VII., fig. 3). and like the San Remo horst the granite is flanked by Tertiary basalts on the north, and ends in steep cliffs 200 to 300 feet high on the south side. This tilted surface must represent an old land surface, since the forces now acting on the granite are not sufficient to erode such a slope. If the line of the Kongwak Fault is continued westwards from Kilcunda, it passes just to the south of the cliffs of Cape Woolamai. It is probable, therefore, that, although the Woolamai granite stock and the basalts to the north of it are now separated from the San Remo Peninsula by a narrow channel about three-quarters of a mile wide (The Eastern Passage), they were once part of the San Remo horst. Under the influence of marine erosion the resistant granite has maintained more or less its original scarp, but the more readily eroded Jurassic strata have been cut back. At the western end of the Peninsula (Griffith's Point) this retreat has been of the order of two miles. At the eastern end (Kilcunda) on the other hand, progradation of the shore has removed the easterly part of the Kongwak scarp from marine erosion. As a result, the southern coast of the Peninsula has slowly retreated hinge-fashion, the pivot being at Kilcunda. This has been furthered by the decreasing height of the original scarp from east to west. The granite stock was left as an island, and has since been joined to Phillip Island by a sandy tie-bar (Hills, 1940, fig. 304).

The Eastern Passage developed by the drowning of the valley of a south-flowing stream. The submarine contours of Western Port Bay, as shown on Admiralty Chart 1707, Folio 98 (1917), indicate that this stream was separated from the main drowned river system that constitutes Western Port Bay by a low interfluve, extending more or less from San Remo to Newhaven. The exposure of basalt on the short platforms west of Griffiths Point at low tide, and in the short platforms on the Phillip Island side of the Eastern Passage, indicates that the stream flowed over a basalt-filled valley, so that there was a valley between Griffith's Point and Cape Woolamai long prior to the incidence of marine erosion. This must have speeded the marine erosion of the southern coast at its western end by concentrating wave attack at this point. A tributary to this valley, also basalt-filled, is exposed in section in the cliffs along the western coast of the Peninsula.

The tide stream through the Eastern Passage flows close to the eastern shore at The Narrows, between Newhaven and San Remo, and then swings in a wide curve over towards the Phillip Island shore. This has developed a shallow backwater on the Peninsula side of the Passage, where an extensive sandbank has been built parallel to the course of the channel. Cape Woolamai protects this sandbank from heavy seas from the south and south-west, while Griffith's Point shelters it on the south-east.

The Contrasted Coastlines.

The coastlines of the Peninsula show a striking difference in the stage of maturity to which they have attained. The northern coastline is more or less mature, while the southern one is still in its youthful stage. The major variable responsible for this difference is the different strength of wave attack to which the two coasts are exposed. The southern coast is subject to severe attack by the heavy seas that frequent Bass Strait, whereas marine erosion of the northern coast results from the much smaller waves of Western Port Bay, with its limited fetch of six to eight miles, and its shallow waters.

Both coastlines appear to be typical fault coastlines, but are actually compound coastlines, resulting from the submergence of a previously block-faulted region (Hills, 1940, p. 223). The faults are younger than the Older Volcanic basalts (Oligocene?), but pre-date the formation of the Bass River and Powlett River Plains. In other parts of South Gippsland the fault system of which these faults are members had affected Oligocene basalts, the Brown Coal series, and sands and gravels regarded as Pliocene (Herman, 1925). At Hedley, the Brown Coal, which has been downthrown by the Gelliondale Fault, is directly overlain by marine Pliocene beds (Edwards, 1939). Presumably, therefore, the faulting is of Pliocene age, which agrees with the mature character of the fault scarps, while the submergence of the down-faulted blocks took place either in the Pliocene or in the Pleistocene.

The Coastlines in Plan.

Both coastlines appear in plan as more or less straight lines, but, whereas the northern coastline shows only broad, shallow embayments, the southern coastline is markedly crenulate. The disposition of headlands and embayments along the southern coastline is largely dependent on fold structures in the Jurassic sediments. The headlands tend to develop where anticlines or domes bring beds of massive sandstone above sea-level, while the embayments occur where synclines or basins carry these beds down, and bring the softer overlying beds down to sea-level. The valleys of the Peninsula tend to develop chiefly in the softer rocks, so that near the coastline the streams occur in the synclines, and enter the sea at the heads of the embayments. As a result, along the southern coastline, high cliffs occur along the anticlinal stretches of the coast, with lower cliffs at the synclines. This further favours the development of embayments in the synclines, since the amount of material to be eroded by wave attack is proportional to the height of the cliffs.

THE COASTLINES IN PROFILE.

Northern Coastline.—The northern coastline is fronted by a gently sloping shore platform with a gradient of about 1 in 650, the 1-fathom submarine contour being at an average distance of three-quarters of a mile from the shore (Text Map). It is developed partly in Jurassic strata, partly in basalts, and has a sloping wave-cut bench ranging in width from 50 to 100 yards (Plate VIII., figs. 8, 10). Much of this is thickly strewn with pebbles of basalt, or, where the bench is cut in Jurassic, of basalt mingled with grit and sandstone. The pebbles are distinctly smaller at the western end of the bench, where it is under the lee of Phillip Island. Where it is exposed to the widest fetch across Western Part Bay, from the north-west, it tends to be swept clean of pebbles, and the edges of the Jurassic strata are exposed. They show undulations in strike, and in places dip to the north at angles as great as 70 degrees. This section of the bench is margined on the seaward side by a "reef" of steeply dipping basalt, formed where the basalt capping outcrops at sea-level. Further east the basalt outcrops in the bench itself, partially covering a narrow ridge of Jurassic sediments, which are exposed along the axis of the ridge.

The beach behind the wave-cut bench is generally only a few feet wide, and along the greater part of the Jurassic outcrops quartz sand is replaced by a fine ironstone gravel. Behind the beach rise cliffs which range from a nip of 1 to 2 feet high (Plate VIII., fig. 9) to sloping cliffs 40 feet high (Plate VIII., fig. 7), and in one place, vertical cliffs 40 feet high (Plate VIII., fig. 10). The more strongly developed cliffs occur along the basalt sections of the coast, where they maintain a uniform height. Two factors cause this. Inland, the basalt forms a flat surface sloping gently towards the sea, so that as the cliffs are pushed back they tend to increase in height. The resistant nature of the basalt causes streams and gullies to develop in the marginal Jurassic sediments rather than in the basalt. Secondly, the basalt in the cliff face is almost completely weathered to clay. As a result, even such small waves as occur in Western Port can undercut the base of the cliffs and cause landslides, which keep the slopes steep. The face of the cliffs is honeycombed with rabbit holes, and edged with talus cones of clay, and a clay beach about three feet wide, showing mud cracks. The vertical cliffs form a stretch about 50 yards long towards the eastern end of the coastline, where the weather basalt shows pronounced columnar and horizontal jointing. They also face the longest fetch across Western Port, and are fronted by a wave-cut bench 100 yards wide, free of boulders, and cut in decomposed basalt.

The Jurassic sediments have been eroded into more undulating forms by subaerial agencies, and form cliffs of variable height with grassy and tree-covered slopes (Plate VIII., fig. 7). Like the basalts, they are subject to landslides, even some distance back from the beach head. Stretches of these Jurassic cliffs are no longer reached by the sea.

Southern Coastline.—On the southern coastline the shore platform slopes much more steeply, at about 1 in 45. The 5-fathom submarine contour occurs at less than a quarter of a mile from the cliff line, while the 10-fathom contour is reached at about half a mile. The wave-cut bench slopes even more steeply in the embayments, and on the headlands is replaced by storm-wave platforms (Plate VII., figs. 1, 2, 4). These storm-wave platforms range in width up to 200 feet, the width decreasing with increase of cliff height (Edwards, 1941). They are widest on the fronts of headlands, and diminish in width as they are followed into the embayments. The cliffs are commonly more than 100 feet sheer in height, and in places exceed 200 feet (Plate VII., figs. 1, 2). Where the slope of the cliff top is landwards it tends to be a dip slope. Parallel major joints, striking at angles up to 20 degrees from north, traverse the rocks in the platforms and cliff faces. The sea has cut channels along these joints, dividing the storm-wave platforms into isolated blocks, and the sides of the headlands tend to collapse along such joint planes, so that they become more or less parallel to the channels in the platforms. Where the rocks overlying the platforms consist of softer shales, erosion along the joint planes tends to develop caves, and in one or two places small natural arches have formed, where the backs of such caves have been breached. The major existing caves occur east of the Punch Bowl (Text Map), and the larger of them has been breached near its back. The Punch Bowl is the remains of a still larger cave, whose roof has collapsed, leaving a circular, crater-like depression about 100 feet deep, with a flat floor composed of debris from the fallen roof.

Rock stacks are noticeably absent, except for a few miniature stacks. This is a feature which is common to most parts of the Victorian coastline that are formed in Jurassic sediments.

Storm ledges occur at a number of points, at varying heights above the storm-wave platforms, where hard bands of rock overlain by softer bands are exposed to occasional wave attack. Honeycomb weathering is pronounced on the storm-wave platforms and at the cliff bases. Higher up the cliffs, where the rocks have been weathered and limonite has been deposited in the joint planes, the infilled joints sometimes stand in relief as intricate three-dimensional patterns. At Griffith's Point, a combination of strongly developed current bedding and closely spaced jointing in massive sandstone has given rise to a peculiar fluting of the cliff-face where it is exposed to wave attack (Plate VII., fig. 6).

The recession of the cliffs is taking place more rapidly than the streams can erode their beds, but since they usually enter the sea at the heads of embayments, over strata of unequal hardness, they tend to descend in a series of cascades rather than form hanging valleys in the cliff-faces. Back from the cliffs rejuvenation of the streams by marine erosion has led them to cut deep gullies. At one point the development of an embayment has beheaded a small stream (Plate VII., fig. 4), leaving a dry valley on the headland. The stream now enters the sea by cascades in the newly-formed embayment.

Sand dunes have accumulated in embayments at one or two places along the coast, but their greatest development is at Sandy Water Holes, where they are still accumulating in the break in the cliff-line (Plate VII., fig. 1). Here they are 50 feet high, and enclose a small marshy lagoon, which is fed by four small streams, ponded behind the dunes.

Western Coastline.—The short length of coast facing the Eastern Passage is more comparable with the northern coast than the southern. At the northern (San Remo) end it consists of a broad beach fronted by sand dunes about 20 feet high. The land surface rises gradually to the south, and this is reflected in the appearance of a line of cliffs, which continues with only one break to Griffith's Point. Where the cliffs begin they are cut in completely decomposed basalt, and are protected from further marine erosion by broad flat sandy beach, which is several feet above high-water mark. Southwards this protecting beach narrows and disappears, and the cliffs are subject to wave attack. Basalt continues to form the cliffs for a short distance. At sea-level the basalt is fresh, but in the cliff face it is extremely decomposed, and shows excellent concentric weathering. The sloping junction of the basalt with the Jurassic to the south, revealed in the cliff section, shows that the basalt infilled a valley in the Jurassic. Close to this junction there is a break in the cliff line, due to a small stream (lateral to the basalt) entering the sea at this point. The cliffs then rise to about 20 feet in height, and slowly increase in height towards Griffith's Point. At the same time, the wave-cut bench widens. As on the northern and southern coasts, the strata are exposed on edge in the wave-cut bench, and show an undulating strike. They dip west at 15—25 degrees (i.e., seawards), and the harder beds, chiefly grits, project above the general level of the beach. The cliffs at the southern end are fronted by sand and heavy talus deposits, while at the northern end a broad sandbank or spit, which is exposed at low tide, extends south-westwards for about a mile, parallel to the tidal channel.

Geology.

The geology of the peninsula was first described by Walthen (1848), who noted the continuous outcrop of "Carboniferous" sediments from Griffith's Point to the mouth of Bourne Creek, and their association with trap rocks (basalt), but was unable to establish their relationship to one another. Selwyn (1854) recognized the "Mesozoic or secondary Carboniferous" age of the rocks, and drew a section from Griffith's Point to the mouth of the Powlett River, showing undulating dips of up to 20 degrees in the "Carboniferous" beds. He also noted the presence of basalts overlying the Jurassic strata, and of dykes intrusive into them. The name "Carboniferous" was applied to the beds because of the general resemblance of the fossil flora obtained from them to the flora of the Sydney coal basin as then known, and the presence in them of thin coal seams. Further references to the district appear in Selwyn's reports for 1855-56 and 1868. A more detailed report, accompanied by maps and sections, and with a description of the lithology of the Jurassic sediments at Griffith's Point, was made by Krause (1872), on behalf of the Coal Commission. Quarter Sheet 67 S.W., showing that the peninsula consists largely of Jurassic strata, overlain on the north side by Tertiary gravels and by basalts of the Older Volcanic Series, was prepared by Stirling in 1892. This Quarter Sheet has been used as the basis of the Text Map. In his accompanying report, Stirling (1893) gives details of the exploration for coal near Kilcunda, and a description of the Jurassic rocks and their flora, together with a reprint of some of Krause's data. Other references to the coal seams are to be found in the reports of Mackenzie (1873), Cowan (1875), and Murray (1884, 1887), while descriptions of the fossil leaf remains found on the peninsula are given in papers by Stirling (1900), Seward (1904), and Chapman (1908, 1909).

The Jurassic Rocks.

Structure.—Two distinct elements of structure exist in the Jurassic sediments of South Gippsland:—(1) a regional tilt in each of the major fault blocks, and (2) folding due, probably, to differential compaction.

Observations at San Remo and elsewhere in South Gippsland indicate that each of the major fault blocks in South Gippsland was tilted during the faulting of the region, so that it shows a prevailing dip of 5 degrees to 25 degrees in a direction more or less at right angles to one or other of the boundary faults. The effect of this tilting is apparent in the streams. Broad rapids, sloping with the dip, like the Tarra Falls, develop on the back-slope streams, while narrow rapids across the edges of strata, and waterfalls, like Agnes Falls, characterize the scarp streams. In some of the tilted blocks, the angle of tilt steepens in the vicinity of the boundary fault, and may become more or less vertical as a result of monoclinal warping along the line of fault. This has been noted along the Yarragon escarpment (Herman, 1925), along the Bass escarpment (Ferguson, 1909), and appears to be the case along the extension of the Bass escarpment that forms the northern coastline of the San Remo Peninsula, where the Jurassic rocks and the overlying Tertiary basalts are found dipping to the north at angles ranging up to 70 degrees along the shore platform, and in a bore put down a short distance back from the shore (Krause, 1872). Modifications of the regional dip have also been caused by lesser faulting within the fault blocks. Such faults are not readily detected except in mine workings and cliff sections. Sections through the Wonthaggi coalfield, however, show that numerous east-west faults, more or less parallel to the major faults of the region, have broken the Wonthaggi block into a number of small steps descending to the north, with sometimes a tilting of the minor blocks, and frequently a warping of the beds into "semi-saucer-shaped sags" (Hunter and Ower, 1914). These half basins face south, and the amount of sag dies away to east and west as the faults die out in these directions. Occasional exposures along the southern coast of the Peninsula show a local steepening of dip due to drag along a small fault. Examples can be seen between Kilcunda and Hoddinot's coal shaft, and on the point west of the Sandy Water Holes.

In addition, as Selwyn (1854) noted, the sediments are gently folded. Stirling (1897) in his report on the adjacent Quarter Sheet 34 S.E., referred to such folding as "an irregular puckering up of the strata rather than regular corrugations formed by anticlinal and synclinal curves." The folds take the form of small, often irregularly shaped, domes and basins of shallow closure, with dips of 5 degrees to 20 degrees, and diameters rarely exceeding one mile, and generally much smaller. Such folding is suggested in many parts of the South Gippsland Highlands by the irregular and sometimes more or less radial arrangement of the dips about certain foci. Where sections have been cut through a series of these domes and basins, as along the coastlines of the San Remo Peninsula, and near Cape Paterson, they appear as alternating anticlines and synclines, sometimes apparently pitching into the cliff, sometimes towards the sea. As many as nine folds to the mile are developed in places along the southern coast of the San Remo Peninsula, while in the vicinity of Cape Paterson they average three to the mile. The apparent pitch may be maintained in one direction for a considerable stretch of the coast, or may be reversed fairly frequently, according to the disposition of successive domes and basins with respect to the cliff sections. Frequently the pitch is in the direction of the regional tilt of the fault block. Thus it is generally to the north, at 10 degrees to 15 degrees along the southern coast of the Peninsula, where the fault block is tilted at about 5 degrees to the north. Near Cape Paterson it is generally to the south at about 20 degrees. Where the apparent pitch is opposed to the tilt of the fault block it is distinctly less steep than where it combines with the tilt. Thus, along the San Remo Peninsula, such apparent south pitch as occurs is of the order of 3 degrees.

Where exposures are not adequate, it may prove impossible to distinguish folds of this type from the " semi-saucer-shaped " sags that accompany the minor faulting on the Wonthaggi fault block. On the Peninsula, however, the edges of the beds are exposed both in north-south and east-west sections. Along the northern and southern shore platforms the beds show an apparent east-west strike with undulations (sinuosity) corresponding to the fold undulations in the cliff sections. Along the western shore platform facing the Eastern Passage, the beds show an apparent north-south strike, with comparable undulations and a variable westerly dip.

This folding developed prior to the faulting and tilting of the region, since the Tertiary basalts infill valleys that cut through the folds. The irregular and minor character of the folding suggests that it is due to differential compaction rather than to earth movements.

Jointing.—The strata are traversed by numerous major joints, frequently in parallel sets. They can be seen only in the cliff sections and on the storm-wave platforms of the southern coast, where they trend more or less north-south, and continue through thicknesses of beds greater than 100 feet, without any deviation of the joint plane in its passage from one bed to another. Presumably these joints developed during the differential compaction of the beds. Minor joint planes are prominently developed in the massive sandstones, and produce more or less rectangular patterns on the smooth surfaces of some of the storm-wave platforms (Plate VII., fig. 5).

Thickness.—The greatest thickness of Jurassic sediments exposed in the Peninsula is along the southern coast, and here the close spacing of the folds, combined with their low dips, limits the thickness of rocks exposed in the cliff sections to about 300 feet. The total thickness is considerably greater, however, since a bore put down at sea-level near Griffith's Point penetrated 857 feet without passing out of Jurassic rocks (Selwyn, 1868, p. 12). The thickness of exposed rocks increases towards the north-east in the Bass Ranges, and the thickness in depth probably grows greater also, since a bore near the Kilcunda Coal Mine was sunk to a depth of 1,158 feet in Jurassic sediments without passing out of them (Stirling, 1892).

Lithology.—As noted by Selwyn (1834), Krause (1872), Stirling (1892), and Ferguson (1909), the Jurassic rocks consist of sandstones, shales, coal seams, and coalaceous beds, conglomerates, and grits.

Sandstones.—The sandstones vary somewhat in character. One variety, which occurs at the base of the cliffs, consists of a massive green rock, over 50 feet thick. It commonly shows pronounced current bedding, as at Griffith's Point, and prominent vertical jointing in two directions more or less at right angles to the bedding planes, so that it breaks away in large rectangular blocks. Close to Griffith's Point this stone was quarried for building purposes as early as 1850 (Selwyn and Ulrich, 1866), and shipped to Melbourne.

Thin sections show that it is highly felspathic. The felspar is present largely as irregular-shaped grains of plagioclase, which is optically positive, with an extinction angle in the symmetrical zone of 10 degrees to 20 degrees, indicating that it is basic oligoclase or andesine. In addition, there are much less numerous grains of cloudy orthoclase, perthite, and microcline. Very occasionally the felspar is graphically intergrown with quartz. Quartz occurs abundantly, but only occasionally as well-rounded grains. Most of the quartz grains are angular, some are composite, and some show well-marked embayment, such as one observes in quartz phenocrysts in acid lava flows. Flakes of bleached biotite are not uncommon, and occasional grains of enstatite are also present. Other minerals noted are epidote, chlorite and zircon. In addition to the mineral grains, there are many rounded fragments of igneous rock, of about the same general size. Some of these are glassy, others are microporphyritic. They are of a uniform type, however, consisting of a fine to glassy ground mass studded with numerous microlites of plagioclase with almost straight extinction. The microlites frequently show flow alignment. The rock is presumably a glassy andesite, or an oligoclase basalt.

The uniform size of the grains points to sorting during deposition, but their irregular shapes indicate that they did not undergo prolonged water erosion prior to deposition. They are now commonly cemented together by narrow rims of zeolitic material which occasionally forms spherulitic growths. The materials composing the sandstone are definitely of igneous origin, and in part are derived from lava flows. Some of the material is almost certainly derived from the nearby Woolamai granite, because higher up in the sequence thin beds of similar sandstone, up to 1 foot in thickness, are intercalated with beds of coarse grit up to several feet thick, in which the component minerals are chiefly coarse allotriomorphic, and often composite, grains of quartz and orthoclase, which can only have come from the Woolamai granite.

The uniform sizing of the grains, combined with their non-waterworn character, suggests that they may have been deposited as volcanic tuff.

Frequently these massive sandstones carry oval or spherical masses, up to 2 feet in diameter, of sandstone of apparently identical composition, and only slightly harder consistency. These "cannon balls" weather out on the surface and give the sandstone a knobby appearance. They are characteristic of the massive green sandstones wherever they occur throughout the Jurassic areas. They occur within the beds and not along the bedding planes, so that they appear to be syngenetic concretions, although they show no concentric structures when broken open. Elsewhere the sandstones carry boulders of foreign origin. These consist of granite, aplite, reef quartz, hornfels, sandstone, grey and black shales, and junks of calcified wood. Ferguson (1909) records the occurrence of two boulders of granite three feet in diameter in sandstone near Kilcunda, and suggests that they are glacial erratics, and Hunter and Ower (1914) record a pebble of an acid dyke rock from the roof of No. 5 workings in the State Coal Mine, Wonthaggi. The sedimentary boulders, in part at least, are derived from Upper Ordovician strata, since Hall (1904) found Upper Ordovician graptolites in some of the black shale or slate pebbles. The granite pebbles can be matched with the Cape Woolamai granite. The boulders are never sufficiently numerous, however, for the rocks to be termed conglomerate, and tend to become fewer in number east of Griffith's Point.

Lesser thicknesses of grey, friable sandstone occur at higher levels in the cliff sections. These sometimes show numerous bedding planes less than an inch apart, sometimes with coaly matter forming a film along the bedding planes. Sometimes they are very closely jointed. Mineralogically, they are similar to the massive sandstones.

Conglomerates.—These outcrop as beds, rarely more than two or three feet thick, intercalated with grits and sandstones on the shore platform west of Griffith's Point, where they are exposed at low tide. Stirling (1892) mapped about five such beds in a distance of a quarter of a mile. The boulders in the conglomerates are well rounded, and up to nine inches in diameter, though generally smaller. They consist of Woolamai granite, aplite, reef quartz, hornfels, and other metamorphosed sediments, shale and black slates. They grade laterally into grits and felspathic sandstones with scattered boulders of similar character.

Some of the beds consist largely of small flat pebbles of soft grey shale in a sandy matrix; and beds of this sort occur sporadically as far east as Kilcunda and Cape Paterson.

Both Stirling (1892) and Ferguson (1909) considered that these conglomerates "comprise the basal members of the south-west margin of the Gippsland carbonaceous deposits," but as Hunter and Ower (1914) have pointed out, this can scarcely be so, because these conglomerate beds overlie the massive sandstones at Griffith's Point, where a bore penetrated 850 feet further down in Jurassic strata. With the grits, however, they undoubtedly mark a marginal facies in the Jurassic since both are derived from the Woolamai granite and the rocks of its contact aureole, and die away eastwards as the distance from the granite stock becomes greater. At the time of their deposition the Woolamai granite and the adjacent Palaeozoic sediments must have formed either an island or a shoreline of the Jurassic lake.

Grits.—Coarse to fine grits are prominently developed along the shore platform facing the Eastern Passage, from Griffith's Point as far as the basalt contact; and they recur from under the basalt in the most westerly outcrop of Jurassic rocks along the northern coast. The bulk of the coarse material consists of irregular grains of quartz 2 to 5 m.m. across, and fragments of large orthoclase crystals of similar size. In addition, small flat pebbles of shale and sandstone, and fragments of more or less calcified wood are common. The beds range up to ten feet in thickness, but are lens-like, and rapidly grade into sandstones. They frequently alternate with beds of sandstone a foot or less thick, when the bases of the successive grit beds are marked by a film of carbonaceous matter, and sporadic junks of coalified or calcified wood.

Shales.—Shales occur as thin black and grey bands, sometimes associated with thin coal seams, chiefly along the eastern half of the south coast. The individual beds are often only one quarter of an inch thick, but the aggregate thickness may be five to ten feet. The shales are often overlain by beds of friable blue-grey sandstone which is characterized by close and slightly irregular rectangular jointing. These two types of rock alternate with bands of harder green sandstone in the cliff faces.

Coal Seams.—Coaly matter occurs as "cakes," films, and discontinuous beds an inch or more thick, accompanied by woody fragments, along the western end of the southern coast. The coaly seams generally occur associated with shaly conglomerates, just above the massive green sandstones, and at the base of grit beds overlying such sandstones. Such coal beds cannot be traced for more than 20 to 30 yards in section. Further eastwards true coal seams are found outcropping, and just west of Sandy Water Holes six such seams occur in the cliff face in a thickness of 50 feet. The thickest seam is two feet thick, and has been encountered in a shaft 100 feet back from the cliff top. A further coal seam outcrops in the cliff face and the bed of the creek just east of Black Head. This seam was 3 ft. 6 in. wide where it outcropped in the creek bed, but when followed inland developed a parting of clay 1 foot thick. It was cut at a depth of 33 feet from the surface in a shaft sunk 100 feet north-west of the outcrop. This seam has been opened up, and is being worked at present on a small scale. Two more seams of workable thickness, 2 ft. 3 in. to 2 ft. 6 in., dipping at 8 degrees N.E. occur to the north-west of the Kilcunda Railway Station, and are being mined. The coal is finely banded, and is a fair quality bituminous variety. No other coal seams of commercial value have been found on the Peninsula, although a certain amount of boring has been done near San Remo and Griffith's Point. The thickest seams encountered in these bores did not exceed twelve inches.

Conditions of Deposition.—The nature of the sediments, and the prominent current bedding in the sandstones, make it clear that deposition took place in relatively shallow water, subject to storms, or to heavy rains. The fact that such sediments are found more than 850 feet above the base of the Jurassic points to steady subsidence within the area during deposition. This thickness of sediments below present sea-level, and the height to which the Woolamai granite projects above present sea-level, point to the existence close by of a steeply sloping shoreline; and the occurrence of seams and films of coalified matter at the base of the grit beds suggests that both the vegetal matter and the material forming the grits was swept down from these steep slopes during periods of heavy rainfall.

The mixture of volcanic matter with granite-derived matter in the sandstones suggests that tuffaceous material was constantly falling into the shallow lake throughout the period of deposition of the Jurassic sediments.

Tertiary Basalts and Dykes.

Basalts of the Older Volcanic Series cover much of the northern part of the Peninsula (Fig. 1) and outcrop at intervals to the north at Stony Point, Cobb's Bluff, Corinella and Queensferry. At Corinella and Queensferry they are overlain by "Red Beds."

Several types of olivine-basalt are present. They include titanaugite-basalts of the Mooroodue type, glassy basalts of the Keilor type, and olivine-basalts of the Flinders type (Edwards, 1939).

A number of basaltic dykes, with a general strike west of north, occur in the Jurassic rocks north of Kilcunda and along the shoreline (Edwards, 1934).

Three such dykes outcrop in the cliffs and shore platform along the southern coast of the Peninsula proper. Two of them are rapidly chilled olivine-basalts. The third, which occurs at the head of an embayment about one mile east of Griffith's Point, is eight feet wide, with well-defined chilled margins about two feet thick at either contact, and distinctly coarser central part, which is more weathered than the margins. A thin section of fresh material shows it to be a coarse-grained olivine-basalt of the Flinders type, in which the olivine, in altering to serpentine, has given rise to flakes of deep brown biotite.

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Explanation of Plates.

PLATE VII.

FIG. 1.—The southern coast of the San Remo Peninsula, looking eastwards from near the Sandy Water Holes towards Black Head in the distance. The dip of the Jurassic strata is inland at Black Head, and seaward at the headland in the middle distance. The headlands are fronted by storm-wave platforms. The Sandy Water Holes lie behind the sand dunes in the foreground.

FIG. 2.—The southern coast of the San Remo Peninsula, looking westwards from Black Head.

FIG. 3.—The profile of the Cape Woolamai granite stock on Phillip Island, showing the northward slope of the granite surface. The view is taken from a storm-wave ledge at Griffith's Point.

FIG. 4.—A beheaded valley, on the headland west of Hoddinot's coal seam. Vertical major joints can be seen in the cliff face and the storm-wave platform.

FIG. 5.—Jointing in the smooth surface of a storm-wave platform cut in massive sandstone at Griffith's Point.

FIG. 6.—Effect of wave erosion on vertically-jointed current-bedded sandstone at Griffith's Point.

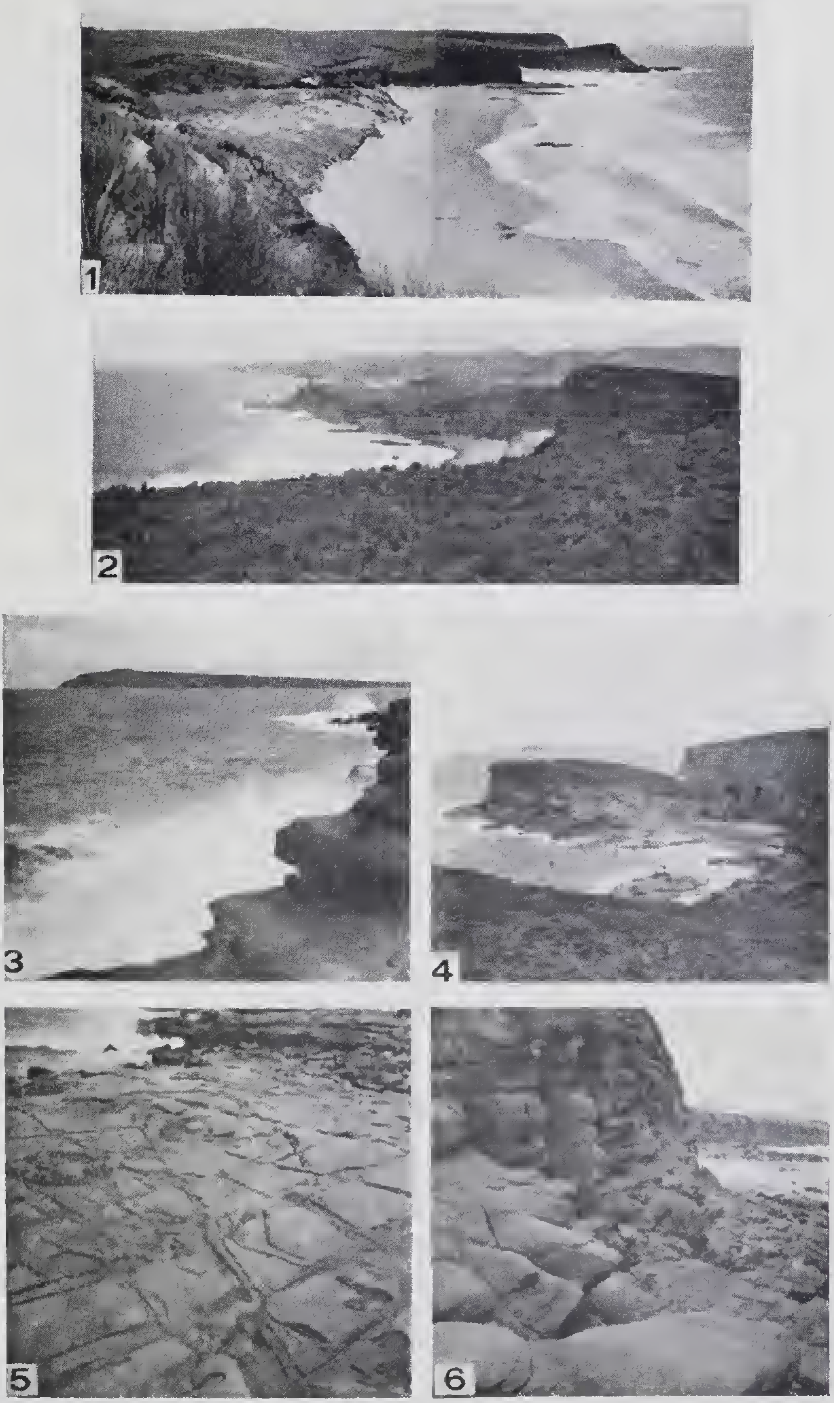
PLATE VIII.

FIG. 7.—A stretch of northern coast of the San Remo Peninsula, cut in Jurassic sediments, looking west at mid-tide.

FIG. 8.—A stretch of the northern coast of the Peninsula, looking west at low tide. The headland in the near background consists of basalt. Phillip Island (Newhaven) lies in the background.

FIG. 9.—Gently sloping cliff, covered by vegetation and fronted by a nip. Northern coast of San Remo Peninsula.

FIG. 10.—Vertical cliffs in decomposed columnar basalt, fronted by a broad wave-cut bench eroded in fresher basalt, on the northern coast of the Peninsula. The grassy cliff slopes on the left are formed on Jurassic sediments, and are subject to landslides. The steeper cliffs on the right are cut in basalt decomposed to clay.



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